DEVELOPMENT OF A RAMI PROGRAM FOR LANSCE UPGRADE*

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ABSTRACT

Improvement of beam availability is a prime objective of the present LANSCE (Los Alamos Neutron Scattering Center) Upgrade. A RAMI (reliability, availability, maintainability, and inspectability) program is being developed to identify the most cost-effective improvements to achieve the availability goal. The beam-delivery system is divided into subsystems appropriate for the modeling of availability. The availability of each subsystem is determined from operation data and assessment of individual component designs. These availability data are incorporated in an availability model to predict the benefit of improvement projects to achieve cost-benefit prioritization. Examination of the data also identifies a comprehensive list of factors affecting availability. A good understanding of these factors using root-cause analysis is essential for availability improvement. In this paper, we will describe the RAMI program and the development of the availability model.

I. INTRODUCTION

Presently, the Los Alamos Meson Physics Facility (LAMPF) is undergoing an availability upgrade [1] so that the accelerator can become a reliable driver for the Los Alamos Neutron Scattering Center (LANSCE). The availability goal is to operate LANSCE at 100 µA with better than 85% availability over an operation period of eight months per year. Because the typical duration of neutron-scattering experiments is 2-3 days, it is important to keep the downtimes longer than 8 hours to less than 10% and those longer than 24 hours to less than 1%. A RAMI (reliability, availability, maintainability, and inspectability) program is being developed to analyze the cost effectiveness of the upgrade. It can be used to plan, monitor, predict, and improve the availability of the LANSCE beam-delivery system.

The RAMI Program is also being used to plan the maintenance and upgrade of LAMPF in the next five years. The purpose is to systematically replace obsolete and unreliable equipment from the LAMPF beam-delivery system so that the Facility can extend its lifetime for another 20 years.

RAMI studies have been carried out previously at LAMPF. In the late 70's, a RAMI program was instituted to bring the availability from 65% to 80% [2]. The system tracked the failures of equipment and the repair cost. The program was later terminated. A review of the recent RAMI studies at LAMPF have been given by Macek in Ref. 3. In 1994, a pilot project, Development of a Reliability, Availability, Maintainability, and Inspectability Model for High-Power Accelerators, was carried out. This project concentrated on a few major subsystems of the LANSCE beam-delivery system as test examples of the RAMI model [4]. The work described in this paper is the continuation of the recent RAMI studies.

II. RAMI PROGRAM

The RAMI Program has three parts: availability model, root-cause analysis, and maintenance plan. The beam-delivery system is divided into subsystems which are collections of individual components. The availability model uses a database that contains the availability data of all the components to predict the overall availability of the beam-delivery system and the subsystems. The commonly used assumptions for models can be found in Ref. [3] and [5]. Predictions should reproduce the observed overall system availability and should be able to predict the gain in overall availability and cost effectiveness of improvements. The availability model will also be used to identify the low-availability subsystems so that a root-cause analysis can be done on the subsystems. The root-cause analysis is an indepth analysis of specific failures which contribute to understanding of failures and suggest improvements. Analysis of the frequency of failure, repair times, and the consequences will aid in the development of an effective maintenance plan.

II. AVAILABILITY MODEL

The database used by the availability model is assembled by first listing all the components in the LANSCE beam-delivery system. Examples of components are power supplies, klystrons, and beam-position monitors. Components with similar location and purpose along the beam-delivery system are grouped into subsystems. They are grouped with enough components to have sufficient availability statistics. Examples of subsystems are injector, PSR (Proton Storage Ring), and Neutron Production Target. Components are also assigned function designators according to their functions. Examples of function designators are magnet, water, and vacuum. Both subsystem and function designators are used in sorting database information to conform with the functions of maintenance groups and with subsystems based on a single design concept. For example, one can easily find the availability of the water system in PSR by selecting all the components that have subsystem designator of PSR and function designator of water and summing their availabilities.

After listing all the components, availability data of these components were collected. These availability data are in the form of MTF (mean time to failures) and MTR (mean time to repairs). They are based on failure rates, manufacturer's data, and estimates by experts. At this point, the assembly of the database is complete and predictions of availability of subsystem can be made in conjunction with assumptions made in the availability model.

The present availability-model database for the LANSCE beam-delivery system has a total of 385 component types

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separated into nine sybsystems. Similar components are counted as one component type. These components are separated into nine subsystems. Subsystem names are given in Table 1. There are 14 function designators (Table 2).

Table 1: List of subsystems in the LANSCE beam-delivery system

Injector	Sector A	Sector B-H
Switchyard	Area A	Line D
PSR	Target	WNR

Table 2: List of functions in the LANSCE beam-delivery system

Aperture	Beamline	Control/data
Diagnostic	Facility	Magnet
RF	Safety	Source
Structure	Timing	Vacuum
Water	Misc.	

The availability model can be benchmarked by comparing its availability prediction with observed availability for subsystems. The observed availabilities of subsystems are provided through operation logs where operators record the times and causes of component failures and repairs. In the present format, the availability-model subsystem and function designators have been chosen to correlate with the operators log for ease of comparison. Figure 1 shows the observed distribution of time-between-failures for subsystems injector and Sector A during the operation in 1994. These data were used to derive the availability, MTF, and MTR for the subsystems.

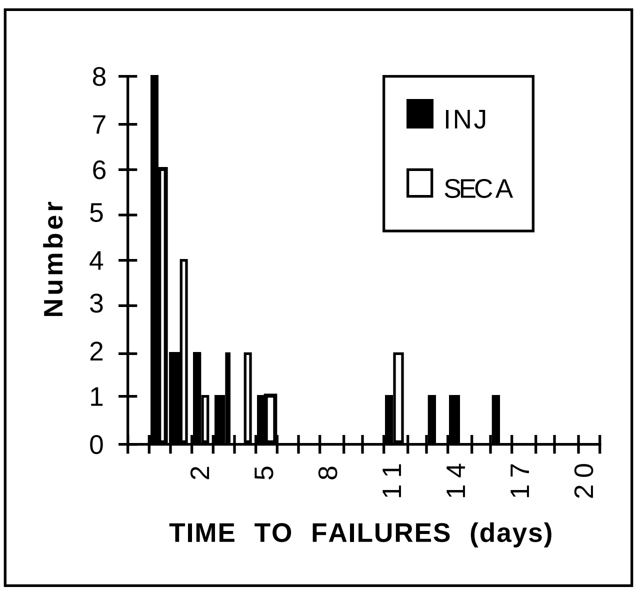

Figure 1: Distribution of time-to-failure for the LAMPF injector and Sector A of the linac

The PSR Pulsed Power System has been studied before using an availability model and is described here as an example [6]. The complete system was divided into four subsystems: switchyard kicker magnets (LDKIs), PSR injection linekicker magnet (RIKI), the 2.8 MHz RF beam buncher (SRHM), and the electromagnetic extraction kickers (SRFK). Table 3 shows the part of the database used for RIKI. The availabilities predicted using the database for the subsystems and complete system were compared to observed availabilities from operators logs (Table 4). Results showed that the prediction of the availability model is within 2% of the observed availability.

III. ROOT-CAUSE ANALYSIS

The availability model and the observed data can identify the low-availability subsystem. A root-cause analysis is needed to identify the failure modes so that improvements can be made. These improvements include a better design, preventive maintenance, and monitoring programs. Assuming these improvements, new MTF and MTR data can be generated and used in the availability model to predict the improved availability. Examples of Root-Cause Analysis can be found in Ref. [3].

IV. MAINTENANCE PLAN

Maintainability and inspectability will be addressed with maintenance plan. Regular monitoring and maintenance are needed to reduce failure and downtime. In an older facility like LAMPF, a sustained replacement program is also needed for equipment that is reaching the end of its useful lifetime. Because of budgetary constraints, the replacement program is not in place yet. A conscious effort has been made, instead, to keep an inventory of spare parts of long-downtime components. A record of these spare parts will be incorporated in the availability-model database. The availability-model database will examined to identify components whose failures are eminent or whose failures have high consequences. In the future, component maintainability, monitoring, and inspectability will also be incorporated in the designs of components.

V. SUMMARY

RAMI analysis is currently being applied to the LANSCE beam-delivery systems. Previous studies and use of this analysis at LAMPF have shown that it can be a useful tool for determining the best assignment of budget and resources to provide maximum beam availability. The current work has established a RAMI model of the entire LANSCE beam-delivery system, based on individual components and their availability histories. The model will be used to predict the impact on availability of the LANSCE beam-delivery upgrades currently in progress and can be used to determine the effect of any future improvements. Components or systems with the probability for high consequence failure can be identified by the model database and root-cause analysis can be applied to the failure modes. Steps can then be taken to avoid or minimize beam downtime due to failures of these components and systems. The model database will also be used to develop a maintenance plan which will provide adequate spares, timely replacement, and preventative maintenance for all beam line components. The end result of this effort should be improved, cost-effective beam availability for LANSCE users over both near and long terms.

VII. REFERENCES

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Table 3: Availability-Model Database for RIKI

Subsystem	Component	Function	MTF (days)	MTR (h)	Spares	Avail.
PSR	**Magnet:**					
PSR	Magnet current connections	magnet	20000	6	Parts	0.999988
PSR	Coils	magnet	10800	340	1	0.998690
PSR	**Charging system:**					
PSR	PS,Sorenson DCR 600-8T	magnet	3600	4	1	0.999954
PSR	PS, Christie 1C015-600EBBX4S	magnet	3600	8	some parts	0.999907
PSR	**Modulator:**					
PSR	Resonate Charge SCR	magnet	3600	8	3	0.999907
PSR	Zener Diode Assembly	magnet	1000	5	3	0.999792
PSR	Charge Recover SCR	magnet	3600	8	3	0.999907
PSR	Freewheel SCR	magnet	3600	8	3	0.999907
PSR	Transfer Chassis	magnet	1800	16	0	0.999630
PSR	**Controls and interlocks:**					
PSR	RIKI01 Run Permit	safety	3600	1	Parts	0.999988
PSR	NIM Crate	safety	1800	8	Parts	0.999815
PSR	Short Nim Crate	safety	1800	8	Parts	0.999815
PSR	**Computer Interface:**					
PSR	CAMAC	control/data	7300	4	?	0.999977
					Sub. Avail	0.997280

Table 4: Comparison of observed availability and availability predicted with availability model. All availabilities are in percentages.

	LDKI	RIKI	SRHM	SRFK	Total
Observed	99.1	98.8	96.5	97.8	92.4
Predicted	97.7	99.7	98.6	98.4	94.6